# MUD LAKE WATER LEVEL RISE

Prepared for Boojum Research Ltd.

By

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During late Summer/early Fall 1999 a number of industrious vagabond beavers built dams across the outflow of Mud Lake. This resulted in a rise in the water level of Mud Lake (ML) of approximately 0.6m.

The question therefore arose: What is the effect of this ML water level rise on the hydrodynamic environment ? In other words: what is the effect on the subsurface inflow from the Tailings Basin (TB) to Mud Lake and the possible increased subsurface outflow from Mud Lake in a northeasterly direction.

## BACKGROUND.

Previous work has shown that ML is a groundwater discharge area for the Kalin Canyon. This burried valley is the main conduit for the transport of contaminated groundwater from TB to ML. The occurrence of the groundwater discharge from this burried valley indicates a significant change in the lateral transmissivity of the valley fill, which can have a number of causes. These are:

- The northern end of ML is the start of Kalin Canyon in bedrock.
- A very significant change in the type of burried valley fill (from very high to low permeable sediment).
- A very significant reduction in the thickness of the permeable sediment.
- A combination of the above points.

No subsurface data exists for this part of the basin, other than surface resistivity surveys, and the exact cause is therefore not known.

EFFECT OF MUD LAKE WATER LEVEL RISE ON SUBSURFACE INFLOW.

*A: Water Levels*

The effect of the water level rise in ML on the hydrodynamic environment of the basin was evaluated by plotting the elevation of the water level of a series of piezometers both inside and outside the TB versus time. The results are shown in Figures 1, 2 and 3. (NOTE: the overal scale of the Y axis is the same). Only the water level in March was considered.

The overall trend from 1987-2000 shows gently rising and falling water levels. A relative sharp increase in the water levels can be noted from 1999-2000. The elevation of the water level in all piezometers is the highest in 2000, except for M31 & M33 (Figs 1, 2 & 3). These latter two piezometers show over the period 1987-2000, for a number of years, elevations of the water level which are considerably higher than in 2000 (Fig.2).

If the longterm trend is considered the piezometers completed in the northeastern part of the TB show the greatest relative increase in the elevation of the water level over the period 1987-2000 (Fig. 2). A significant increase occurred from 1993 onward, which,as pointed out in a previous report, was caused by an increase in the elevation of  the water level in Decant Pond.

Piezometers M50 and M54 show the least amount of variation of the elevation of the water level over the period 1987-2000 (Fig. 3). M54 is a shallow piezometer completed on the shore of Confederation Lake. The elevation of the water level in this piezometer reflects primarily the changes in the elevation of the water level of Confederation Lake. The longterm trend shows a slight rise. M50 is a deep piezometer located in the old town site. No other deep piezometers are present between M50 and the shoreline of Confederation Lake. It is, however, suspected that groundwater flows from M50 toward the lake. Consequently, the elevation of the water level in the lake will exert a strong influence on the water level in M50. This is obvious from Figure 3, which shows a considerable parallelism in the plots of the elevation of the water levels of M50 and M54. March 2000, however, shows a slightly greater increase in the elevation of the water level of M50 as compared to M54 and the trend in previous years.

In conclusion, it is obvious, that changes in one part of the environment, i.e. the rise in the water level of Mud Lake, affect the total hydrodynamic environment to various degrees.

The frequency of water level measurements was drastically reduced a number of years ago, because longterm trend analysis had shown relatively predictable pattern. However, the reduction in the frequency had not counted on the activity of a number of beavers who decided to settle in the northern end of ML. As a result the data base is somewhat meagre to follow the effect of the building activity of the beavers. Fortunately, there is some data available over the period from March-May, which also include the Spring melt recharge event. This is illustrated in Figure 4. As can be seen in this figure, the elevation of the water level in the piezometers has been dropping steadily from 1996-1999. However, a sudden and significant change occurred from 1999-2000 over the time interval from March-May.

*B. Gradients*

The change in the water level of ML during 1999-2000 has significantly affected the hydraulic head distribution as shown above. The hydraulic head distribution, in turn, determines the gradient along a specific flow path. If no changes occur in the transmissivity and the cross-sectional area along the flow path, then the rate of groundwater flow is determined by the gradient and its changes with time.

The changes in the gradient from February-May over the period 1996-2000 is only illustrated for a small number of piezometers. Figure 5 shows the changes in gradient between M69, M72A & M83A and M79. This figure shows that the gradient can vary considerably over the period from February-May within one year and between years.

Although data for specific dates (Feb.-May) for each year over the period 1996-2000 is not consistently available, Figure 5 illustrates that the gradient displays a considerable range for each of the years in the period 1996-1998, but becomes much more muted for the period 1999-2000.

This becomes very evident if only the gradients in March and May are considered (Fig. 6). This figure illustrates that the gradients in March are more or less the same over the period from 1996-2000, but differ considerably from those in May. The May gradients show a significant increase from 1996-1998, but a much smaller increase from 1999-2000. The much lower values of the “May” gradient in 1999 may be due to the date of the measurement (April 21), which, therefore, may not reflect the total effect of the Spring melt in that year.

It is unfortunate, that no information is available on the water level in ML over the period from 1996-2000, because of the effect this water level has on the hydraulic head distribution. Another factor which strongly influences the hydraulic head distribution is the annual Spring melt and subsequent recharge. This will be discussed in more detail below.

SPRING MELT.

The annual Spring melt is the main and most important groundwater recharge event. To determine the relationship between the precipitation and the elevation of the groundwater in March a number of steps have to be undertaken.

*A: Relationship between water levels in piezometers in October and March in the following year.*

Figures 7 and 8 show the elevation of the water level in October and March of the following year in 2 sets of piezometers within the TB. The October value was used to represent the elevation of the groundwater after no further recharge would occur, because of the onset of Winter. The March value shows the elevation of the groundwater prior to the Spring recharge event and the March data has been used extensively above. Both figures show that the magnitude of the elevation of the water level in March is consistently lower than in October of the previous year. Furthermore, where sequential data is available, it shows clearly that the trend from year to year in October is reflected in the corresponding March data for the following year.

*B: Precipitation Data.*

Figure 9 shows the precipitation data for the period 1991-1999. Three different traces are shown. The total winter precipitation represents the interval from October 1 to March 31 of the following year. The total summer precipitation represents the interval from April 1- September 30 in the same year and the total precipitation is the sum of the winter and summer precipitation and covers the period from October 1 to September 30 of the following year. The winter precipitation is plotted on March 31 and the summer and total precipitation are plotted on September 30 of the same year. It is obvious that the bulk of the precipitation falls during the summer, but previous analysis of summer precipitation versus a rise in the groundwater level has shown, that only major storm events are reflected by an increase in the elevation of the groundwater level.

*C: Relationship between precipitation and elevation of groundwater.*

Figure 10 shows the elevation of the water level in a number of piezometers superimposed on the precipitation data. This figure clearly shows that the trend in the magnitude of the winter precipitation, i.e. the amount of water available during Spring melt, is beyond doubt reflected in the trend of the elevation of the water level in the piezometers in October of the same year, except in 1999. The correlation between the winter precipitation and the elevation of the water levels is much better than the total precipitation.

The significant rise in the elevation of the water level in October 1999, cannot be accounted for by the precipitation data. Based on the trend of the precipitation data the water level in October 1999 should have been lower than in 1998. In other words, the observed rise in the elevation of the water level in October 1999 is solely due to the handiwork of the beavers in the outflow area of ML, which resulted in a rise in the elevation of the water level of ML.

As was pointed out above, there is a good correlation between the water level data in October and March of the following year. The significant rise in the water levels of the piezometers in March as shown in Figures 1 and 2 is entirely due to an increase in the elevation of the water level of Mud Lake.

If the elevated water level of ML was allowed to be maintained by the beavers, a new equilibrium would be established in the future and trends between precipitation and water levels would also be re-established. Under these conditions the overall elevation of the water level within the TB would rise.

Destruction of the beaver dam(s) will drop the water level in ML relatively rapid. As a result a disequilibrium will be created between the TB and ML, which, in turn, will result in a slug of contaminated water moving along Kalin Canyon towards ML due to an overall lowering of the water level in the TB.

## EFFECT OF MUD LAKE WATER LEVEL RISE ON SUBSURFACE OUTFLOW.

Just as the rise in the water level of ML affects the inflow into the lake, it will also increase the subsurface outflow from the lake due to the increase in hydraulic head caused by the increase in the elevation of the water level. If permeable continuous sediments are present in the subsurface under the northern part of ML and continue in a northeasterly direction than the rate of movement of contaminated water will also have increased.

Unfortunately, there is no stratigraphic information available in this area. Also, there are no piezometers present. The only information which is available, is the result of a surface resistivity survey. To determine if any movement of contaminants has occurred, it is suggested that additional resistivity surveys are conducted along the same lines as previously. Only if significant changes are observed between the two surveys would further test drilling and piezometer construction be required in the future.

FIGURE 1. Elevation of water level in March in selected piezometers over period 1987-2000

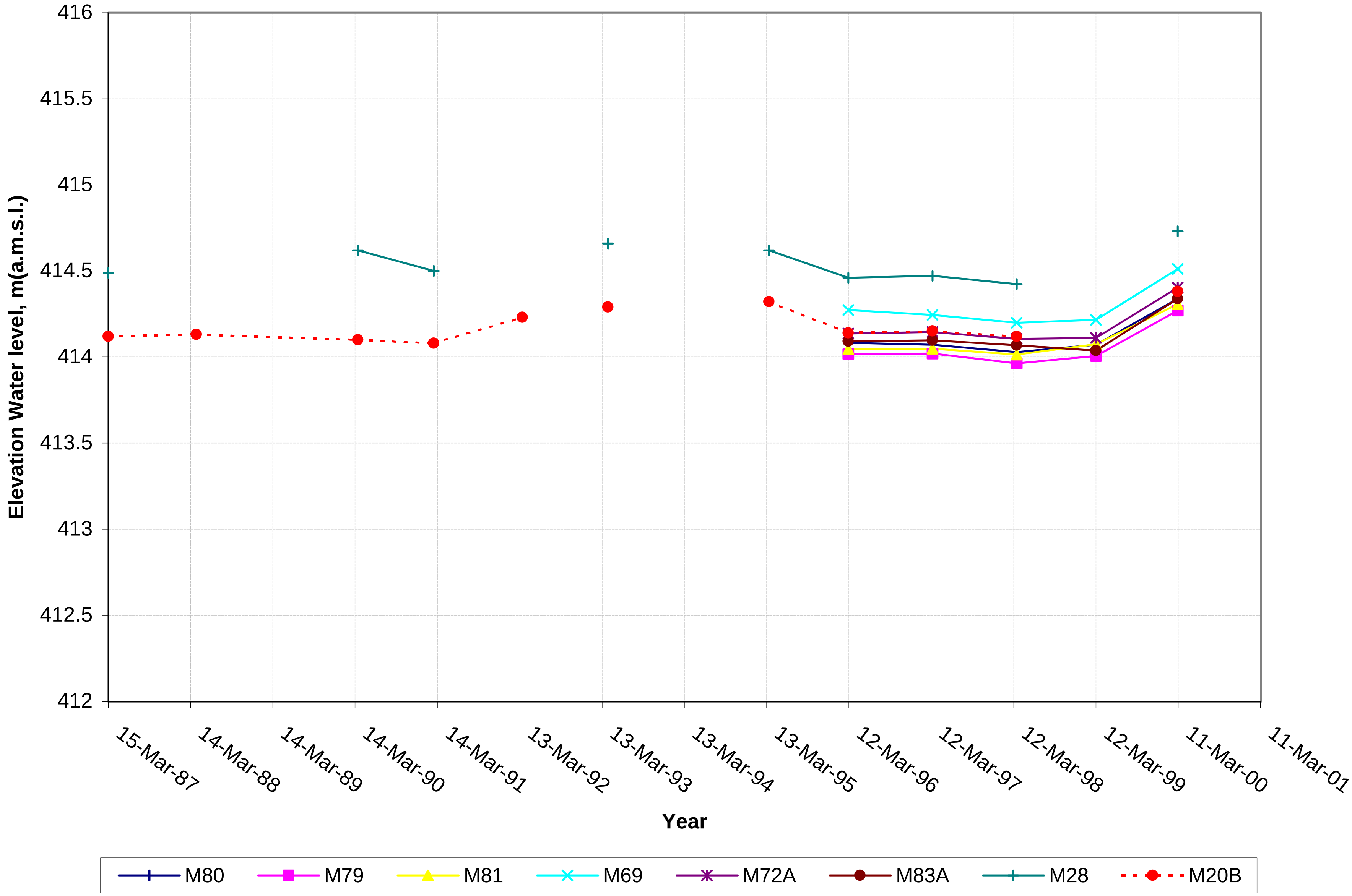

**FIGURE 2. Elevation of water level in March in selected piezometers over period 1987-2000**

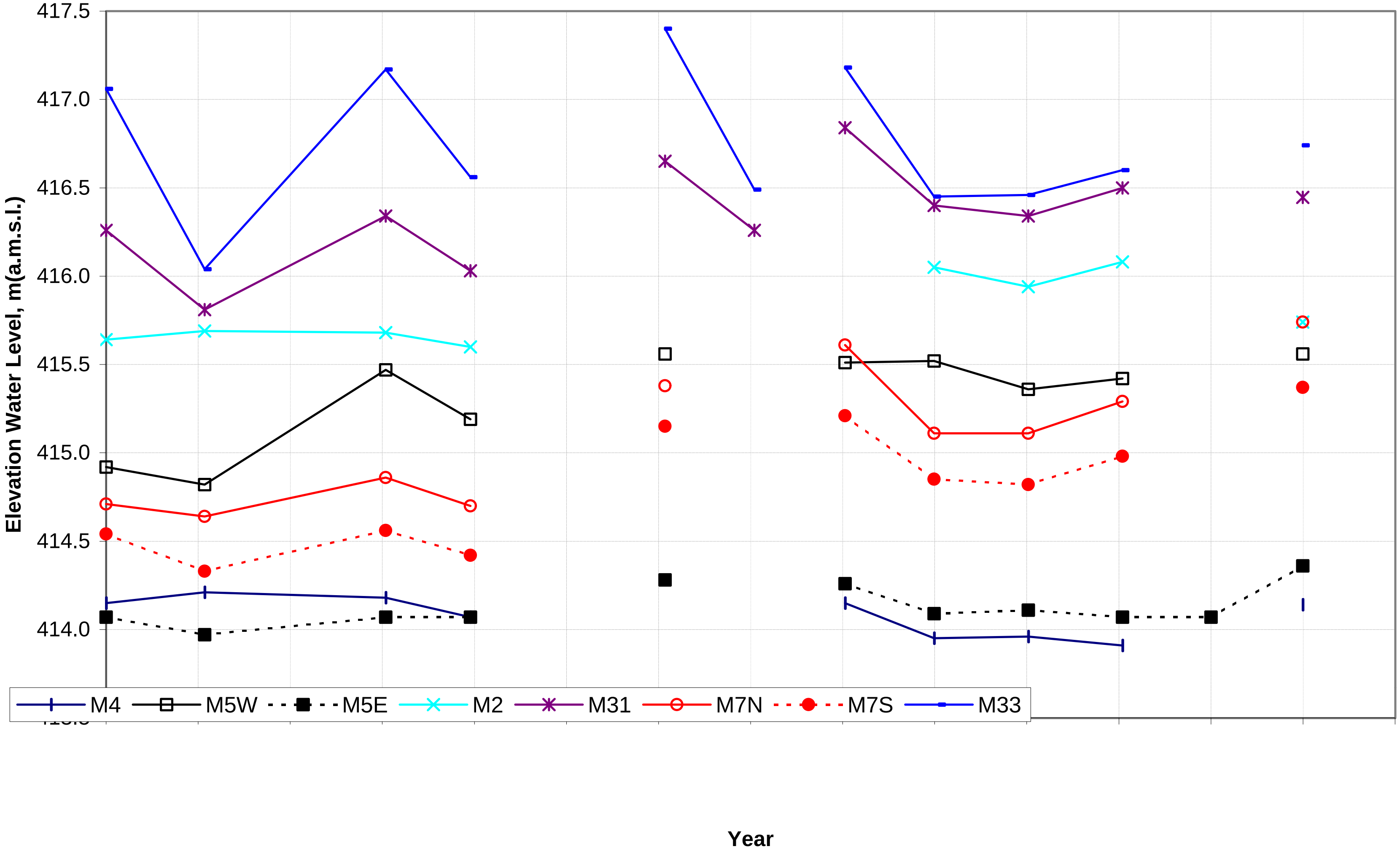

**FIGURE 3. Elevation of water level in March in piezometers M50 & M54 over period 1987-2000**

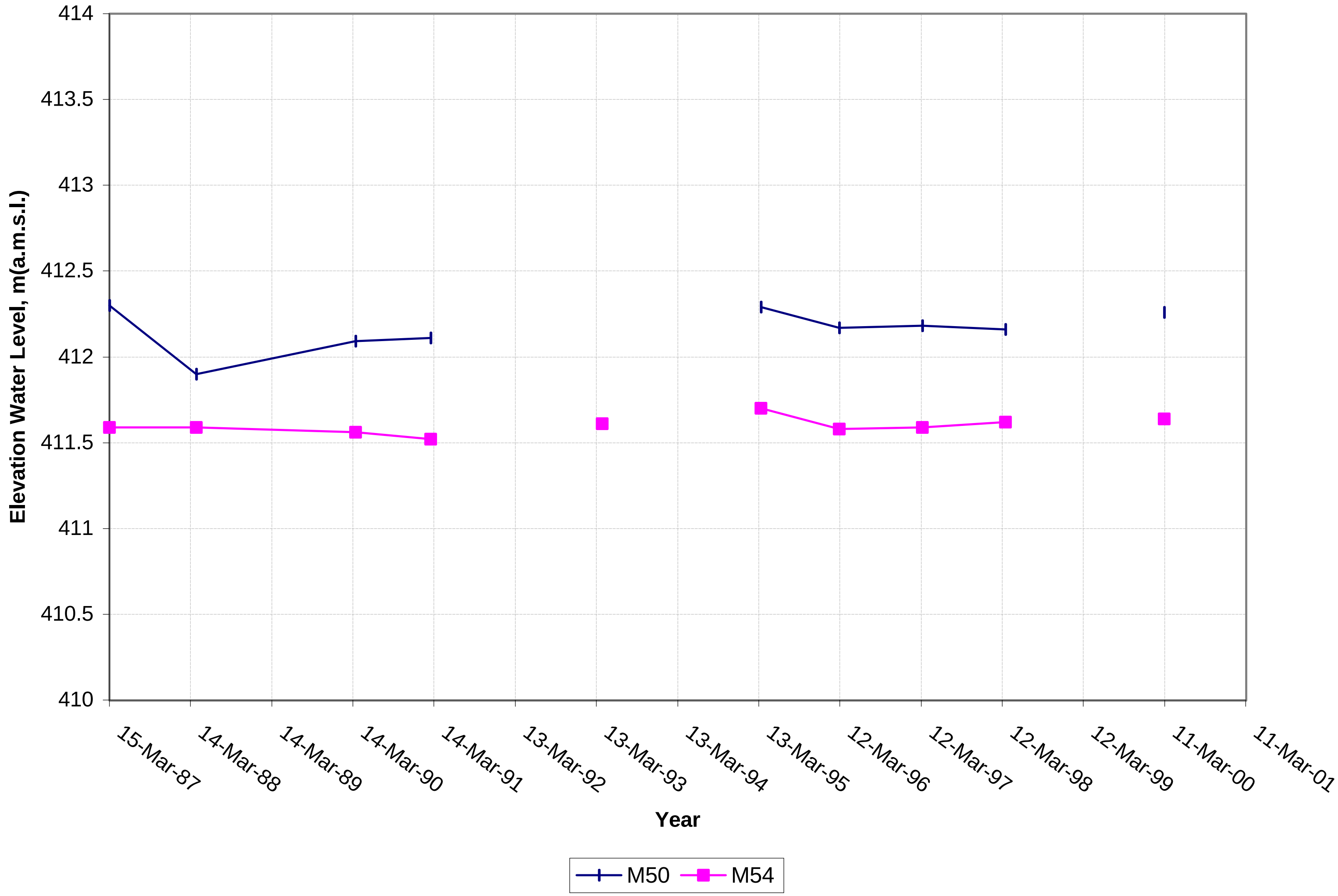

**FIGURE 4. Elevation of water level in M5C, M39A, M69, M72A, M80 and M83A over period from March-May (1996-2000)**

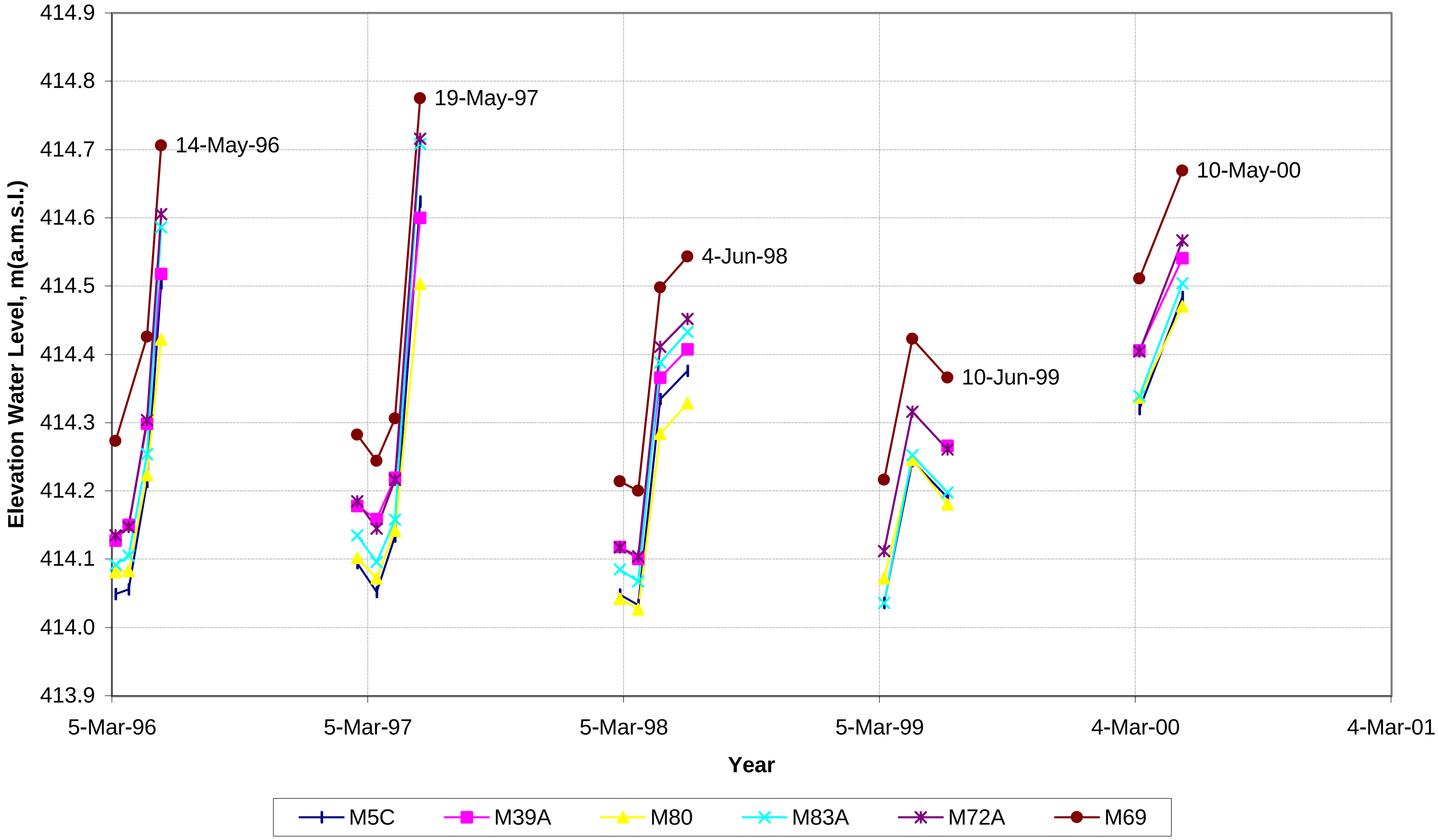

**FIGURE 5. Gradient between M69, M72A & M83A and M79 over period from February-May (1996-2000)**

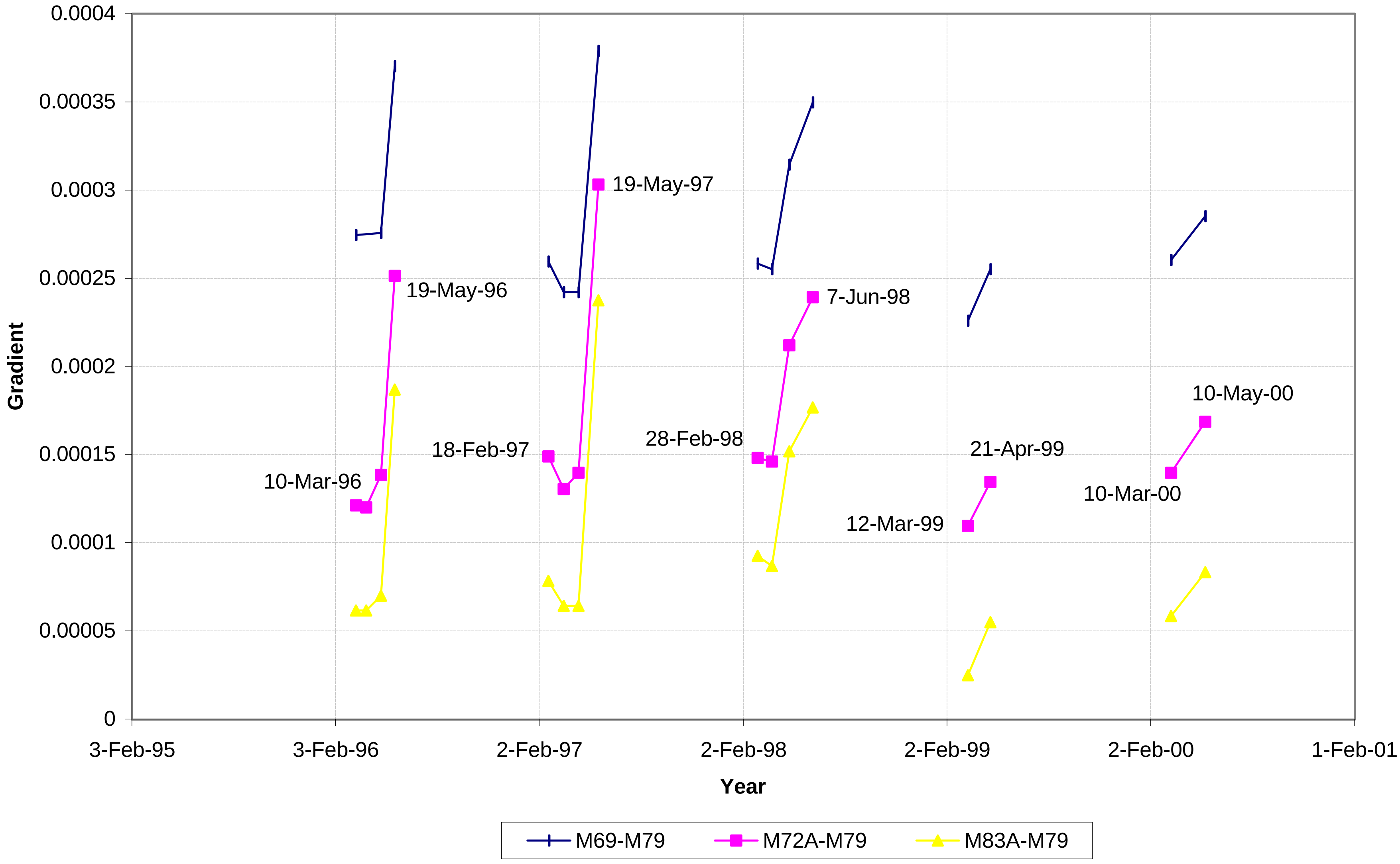

**FIGURE 6. Gradient between M69, M72A & M83A and M79 in March (dashed) and May (solid) over period 1996-2000**

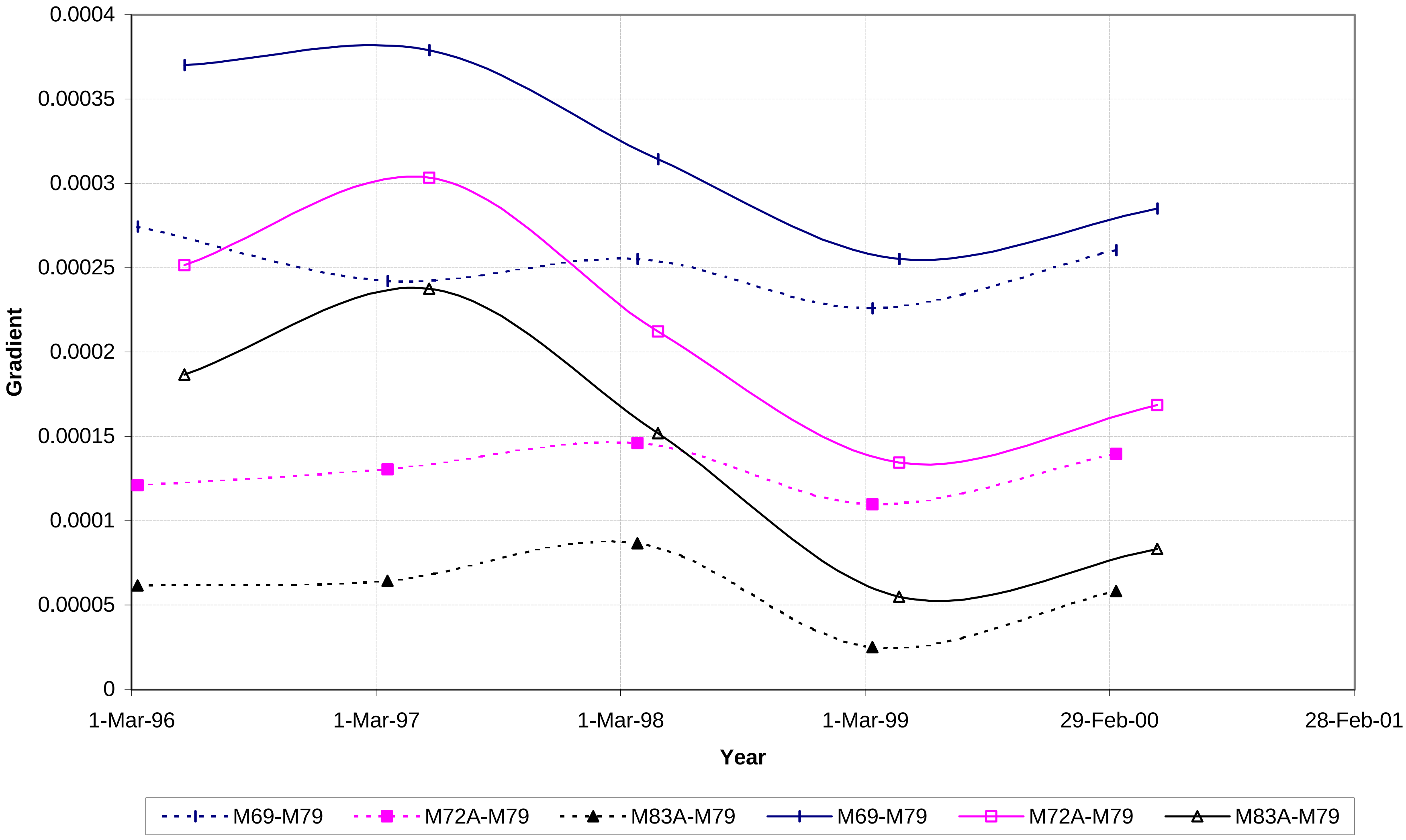

**FIGURE 7. Elevation of water level in October and March of the following year in piezometers M7S & M7N over period 1986-2000**

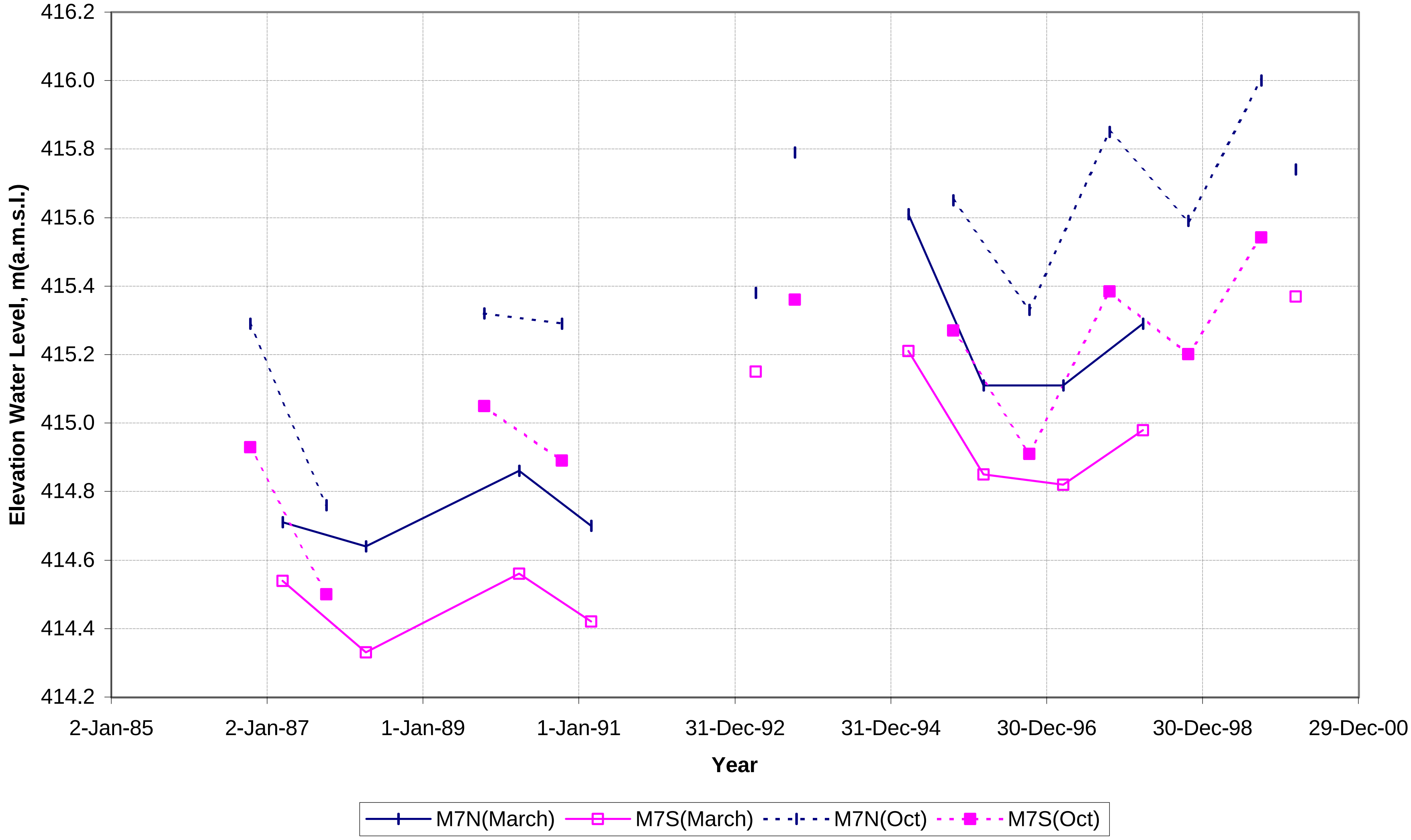

**FIGURE 8. Elevation of water level in October and March of the following year in piezometers M5W & M5E over period 1986-2000**

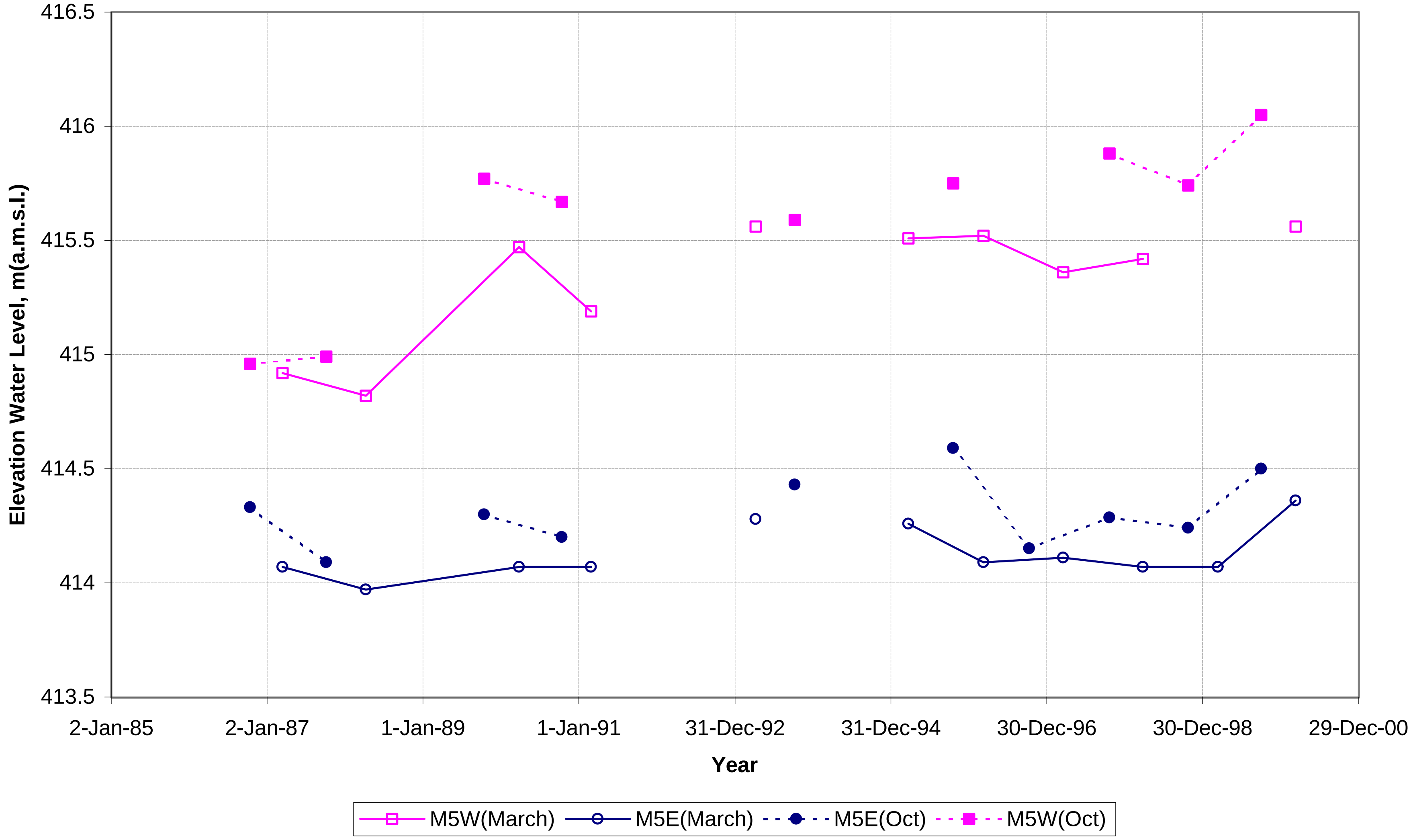

**FIGURE 9. Total winter precipitation for interval October 1-March 31 (following year), total summer precipitation for interval April 1-September 30 (same year) & total precipitation for interval October1-September 30 (following year) over period 1990-1999**

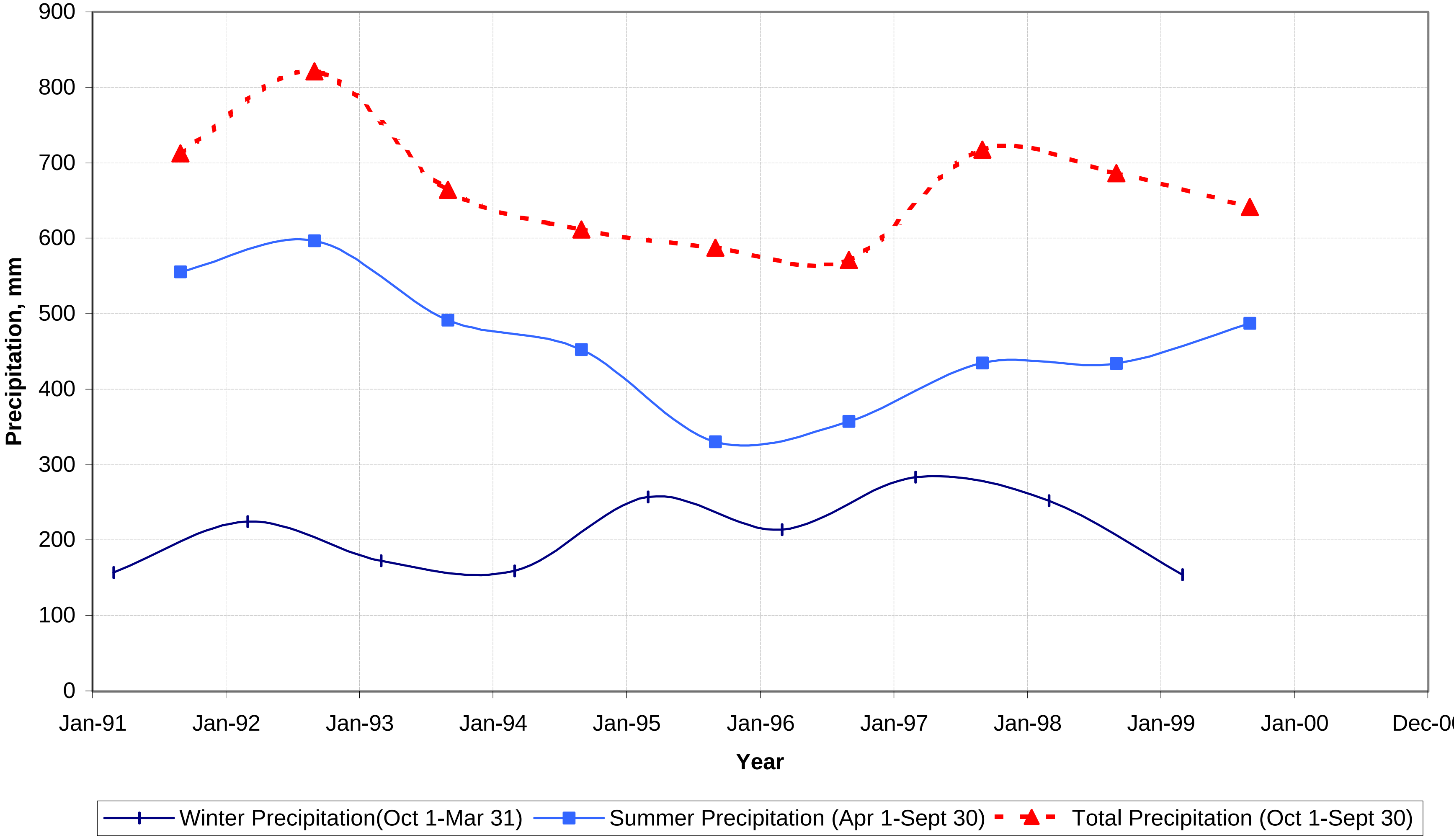

**FIGURE 10. Total winter precipitation (Oct. 1-Mar 31), total summer precipitation (Apr.1-Sept. 30) & Total precipitation and elevation of water level in piezometers M5E & W and M7N in October over period 1990-1999**